DOCUMENT RESUME

ED 209 257 TM 810 702

AUTHOR Montague, William E.; And Others
TITLE After Years of Instructional Research Do We Know More than Grandma Did About How to Teach People?
PUB DATE 15 Apr 81
NOTE 38p.; Paper presented at the Annual Meeting of the American Educational Research Association (65th, Los Angeles, CA, April 13-17, 1981).

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Criterion Referenced Tests; *Educational Research; *Instructional Development; *Instructional Improvement; Models; Postsecondary Education; Research Problems
IDENTIFIERS Meta Analysis; Naval Training; *Navy

ABSTRACT

Many articles have appeared in the educational, instructional, and psychological literature questioning the adequacy of the technology available for devising instruction, and the usability of the instructional research literature as a source of the technology. A systematic planning model is a useful framework for organizing what has to be done to plan and develop instructional programs. It also provides a way of reviewing and summarizing available research to evaluate its usefulness for carrying out the tasks of instructional development. This systematic planning approach has changed substantially the way in which instruction is designed and developed in military organizations, and the way in which instruction is carried out. Researchers have been investigating how people process information and learn, with the long range intention of discovering techniques applicable to the development and delivery of instruction. Research is "relevant" if the tasks studied are chosen from tasks actually taught; or if it uses a detailed, intensive analysis of the task, and of the moment-by-moment behavior generated by subjects performing the task. Current research trends are emphasizing process analysis, and will result in more "relevant" research. (BW)

**********
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
**********

ED209257

AERA Invited Address 15 April 1981
Session 23.02

# After years of instructional research do we know more than grandma did about how to teach people?

William E. Montague
John A. Ellis
and
Wallace H. Wulfeck, II
NAVY PERSONNEL RESEARCH and DEVELOPMENT CENTER
San Diego, CA 92152
*1

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
☒ This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.
• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

## 1. Why are we concerned?

Do we know more than Grandma did about how to teach people to do things? A title of this sort deserves an explanation. It raises the issue of whether, as a result of the numerous studies of learning, instruction and development of related theories, we have developed techniques for teaching people that are any more effective than older techniques. There is considerable doubt that we have.

### 1.1 Origin of concern in carrying on instruction and course development in the Navy.

We became interested in this issue when we were confronted with the tasks of evaluating the quality of Navy training courses, and making recommendations about how to develop instruction to train Navy personnel. Planning, developing, and delivering training, and maintaining the quality of training in the military are formidable tasks. A constant flow of new personnel must learn to operate and maintain an increasingly complex array of hardware. For example: here is a quotation from a recent review of military training from Rosenblum (1979):

> In FY 1980 the services plan to accomplish more than 230,000 student man years of training (approximately one and a quarter million students) in almost 7,000 civilian and military training courses, ranging in duration from a few days on a military installation to up to three years at a civilian university. Seventy-five percent of individual military training in schools is accession oriented; that is, training which is designed to turn a civilian into a productive service

---

*1. The comments and assertions contained in this paper are those of the authors and should not be construed as official or as relecting the views of the Navy Department or of the United States Government.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY
W.E. Montague
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."



TM 810 702

member (officer or enlisted) with a usable military skill. For FY 1980, a military and civilian staff of approximately 182,000 persons is programmed to support the individual training effort.

The figures above result in costs of about 6 billion dollars per year. Further, they don't include on-the-job training (either individual or team/unit). When these are included, the cost is about $9 billion. Because of these high, visible, costs, there is constant pressure for making military instruction efficient as well as effective. Military personnel in training are paid, and these costs are charged against "training" and are considered to be unproductive in terms of the military missions. In a course which graduates 25,000 students a year, if an hour of instructional time can be saved, this results in a cost saving of nearly a quarter of a million dollars.

These factors have forced attention to improved methods of planning and evaluating instruction, and to new techniques for making things work better. They have motivated the creation of organizations, mechanisms, and resources for the systematic improvement of the instructional process (Branson, Rayner. Cox, Furman, King, & Harnum, 1975, Branson, 1979).

We are concerned with how to assist in this large and complicated enterprise. Our main focus is on how to carry out the process of instructional development effectively; this focus includes how to identify particular knowledge and skills that should be taught, how to assess learning, how to design instruction which communicates to learners, how to manage and mediate learning, how to direct students' study techniques, how to adapt instruction to individual differences, how to conduct external evaluation of training programs, and with a variety of other issues. Because of this focus, we are naturally concerned with how research can contribute to the process of instructional development. Each new research article raises questions in our minds about its usability; about how to adapt the research results to instructional development.

1.2 Concerns voiced in the literature about the quality of instructional technology and the relevance of instructional research.

We are not alone. Many articles have appeared in the educational, instructional, and psychological literature questionning the adequacy of the technology available for devising instruction, and the usability of the instructional research literature as a source of the technology.

For example,

Gagne(1980) suggests that "...most educators who take a look at

the current status of educational research agree that its outcomes appear to have no more than a small direct influence on school practices..."

Getzels (1978) "The skepticism of educators about the bearing of research -- and particularly of basic or theory- oriented research -- on the operation of schools is quite extraordinary."

Gropper (1980) asks: "Is instructional technology dead?"

Chadwick (1979) discusses "Why educational technology is failing..."

Forman and Chapman (1979) ask: "Research on teaching: Why the lack of practical results?"

Montemerlo (1979) wonders whether the instructional technology is a "...tool or tyrant."

Harmon (1979) suggests that there are problems with the model of psychology underlying the technology. That the behavioral performance analysis model is based on "...dated concepts of the behavioral psychology of the early sixties."

1981 AERA Symposium (Division C) 15.21: Psychological theory and educational practices: Is it possible to bridge the gap?

There seem to be a number of problems identified in various papers:

(1) There seems to be skepticism about the technology of instructional development, because it is based on older, unpreferred "theories" of learning and teaching, and/or because the usefulness of any research models or theories is doubted.

(2) There seem to be "attitudes" among academic researchers which treat the importance of application and usefulness superficially. This yields a research literature that uses artificial paradigms and that concentrates on the learning of irrelevant tasks. This results in research findings that are difficult or impossible to translate into useful rules or prescriptions for instructional development.

(3) Researchers often hold a "feedforward" view of research, i.e., that teachers or instructional developers can use information directly as the research report presents it (Schutz, 1979; Greeno, 1978).

(4) There is a general ignorance among researchers of the problems encountered in putting research knowledge into practice, in terms of the guidance needed to use techniques,

of how to communicate with the users, etc.

(5) Reviewers of instructional research express concern that research has not had large and direct effects on teaching in schools (e.g., Clifford, 1973; Getzels, 1978).

These factors create an atmosphere that raises uncertainty, among teachers, instructors, managers of schooling, and funding agencies, about the worth of supporting research and technology. The result of this uncertainty in the current political climate will be that support for research and technology development will wither in the face of ever increasing belt tightening, unless it can be demonstrated that substantial gains in efficiency and effectiveness have been realized.

Our view is that it is in our own self interest to be concerned with the usability of the knowledge and theories in psychology and instructional psychology. These disciplines should provide bases for devising techniques for determining what must be taught and how to go about it. Research, in large part, can be viewed as a support activity for the system that delivers instruction (Slavin, 1978).

Glaser (1976,1978a,b) called for a "linking discipline" to help with such efforts, we think the time has come to take that "call" seriously. Although efforts have been made toward developing such a technology there are growing doubts as to its efficacy. In large part, this can be attributed to the lack of concern for relevancy and application mentioned a moment ago. But, such a technology also depends on organized, systematic attempts to translate what is known about learning into prescriptions that can be implemented. There is a need for a synthesizing organization or scheme to help focus research attention on problems important in application, and to help collect and translate research knowledge into useful forms for designing instruction.

In summary so far, we started with the need to assist the system that provides instruction in the Navy. This forced us to ask what the contribution of instructional research has been to the technology of instruction. Others have been asking similar questions and some have been critical of whatever technology exists, and the usefulness of the research base on which it rests. In the following sections we will assert that a systematic planning "model" is a useful framework for organizing what has to be done to plan and develop instructional programs. It also provides a way of reviewing and summarizing available research to evaluate its usefulness for carrying out the tasks of instructional development.

## 2.0 A system planning framework as a framework for discussion

A detailed and precise planning system is necessary to organize and develop instructional programs or curricula. At a global level, all instruction, whether developed formally or informally, goes through the same stages: determination is made of what students are to learn, how the learning will be assessed, and how to go about arranging the conditions for learning to take place.

However, the quality of much of the instruction developed for education and training in the past has been recognized to be erratic and heavily dependent on the expertise of the person or persons devising it. Until recently, instructional design was an intuitive, artistic process. One problem with this approach is that the intuitions of people about what and how to teach can vary widely. The resulting instruction may then teach irrelevant things, or perhaps leave out things very important to people's later performance. A second problem is that people's artistry also varies. While one artist may design instruction that communicates very efficiently, another person may produce "instruction" that is barely comprehensible. Finally, the traditional schooling system also does not easily make room for much change within the classroom.

During the mid 1950s trainers and educators began to develop techniques to correct these problems. Their goals were to stabilize, structure, and refine the process of instructional development, to insure the relevancy of training for peoples' jobs or roles in society, and to make instruction efficient through systematic planning and application of research knowledge. Current systematic instructional planning procedures or "models" stem from a combination of Operations Analysis and Systems Engineering methodology developed and used for the production and evaluation of new hardware systems during and after the second World War (Churchman, 1968), and from a concern for producing a technology of teaching among behaviorists (Glaser, 1978b). Techniques are derived from the body of research and theoretical summaries available (Gagne and Briggs, 1979).

The use of this methodology for instructional program development began in the late 1950's and gradual formalization of the procedures began and is continuing at the present time. The assumption was made that specifying the procedures in detail would enable non-master instructors to be able to develop effective instruction. A large number of "proceduralized" instructional design and development manuals were written during the last 15-20 years(see: Montemerlo & Tennyson, 1976; Andrews & Goodson, 1980). The idea of developing instruction this way appealed to managers of military education and training because most of their courses must be developed by people who are naive in instructional psychology and related technologies. They are subject matter specialists alone, and remain in any assignment

for no longer than a couple of years. In addition, training efficiency as well as training development efficiency is a major concern because students are paid and new courses are being developed continually.

We are all familiar with the various names these procedures go by: "course design procedures," "curriculum engineering," "systems approach to training," and "instructional systems design," among others. Although there are differences among them that have been summarized recently by Andrews and Goodson (1980), they all share a common approach (cf., Gropper, 1977). They recognize that some analytic effort is needed to specify what must be performed by learners after instruction. Job descriptions or curriculum goals form the basis for the derivation of specific learning objectives, and those in turn, determine how the learning will be tested, and the form and content of the instructional presentations. Once it is all put together, the instructional program is implemented and graduates' later performance is assessed to be used to correct program deficiencies. Thus the approach is considered to be "cybernetic" in nature containing "...an input-output-feedback cycle..." (Andrews and Goodson, 1980, p.2).

## 2.1 The tasks of designing instruction.

For the purposes of this presentation, we think that it is useful to use this framework to help us organize and understand the complexity of instructional program planning, identifying the tasks and roles that people and organizations play. It can be used, not only to guide instructional development, but also can provide a means of organizing and evaluating the state of our knowledge in instructional psychology and other appropriate disciplines, and thereby, help identify areas of needed research.

It is important to emphasize our belief that sytematic planning approaches make no particular committment to any particular theory of instruction or of learning. This is so, even though there was early emphasis on using prescriptions for teaching derived from behavioristic "learning theory" (Glaser, 1978b). These approaches also do not rule out the possibility that instruction may be adaptive to individual's prior knowledge, learning abilities, study strategies, etc., even though they have been wrongly criticized for doing so (McDonald-Ross, 1973).

A final assumption is that the system planning framework offers a general description of the "job" of designing instruction and it applies to all types of instructional development, from instructional programs in elementary school to those needed in military training. It is a performance-based approach that is applicable to developing instruction to teach simple tasks and also provides a reasonable means of systematically planning instruction for complex activities, such as problem solving and reflective thought (Gagne, 1979).

Now let's look at an attempt at listing the tasks involved in designing instruction. Table 1 is derived from one presented by Andrews and Goodson (1980, p. 5).

---

INSERT TABLE 1 ABOUT HERE

---

I'd like to briefly review the list. What we want to point out here is the need to consider the source of techniques for carrying out these tasks. Where does one find the procedures for accomplishing these tasks? The list merely represents a listing of the high level tasks that must be accomplished at one time or another in designing and developing instruction. It does not represent the dynamic interplay between the tasks during development.

It is true that some useful prescriptive techniques have been derived for these tasks, but they do not seem to be as complete or as adequate as we would like. This is one reason that so many versions of the model have been created. Using the system model as a frame of reference we should be able to identify the deficiencies in the techniques used to carry out the process. We can then determine where advances are needed.

## 3.0 The usefulness and difficulties in applying the system planning model.

In trying to utilize the system planning model for managing the design and development of instruction, the military services have provided a practical "test" of the technology. This "test" has revealed advantages as well as shortcomings. The primary intent in implementing the model on a large scale was to guarantee relevancy of course content to jobs or tasks people had to do, to save money by reducing course content to "essentials," to standardize curriculum development methods so that they could be applied consistently and reliably by developers who are not instructional experts or "artists," and finally, to improve the efficiency and effectiveness of the resulting instruction.

The main purposes of attaining job-relevance and reducing content to essentials were sometimes achieved, and efficiencies were occasionally obtained through self-pacing. Evaluations have shown that when self-paced courses are compared with traditional group-paced lecture courses, they save considerable time, and students achieve the same or slightly better test performance. For example, in comparisons done in 48 military training courses, achievement in self-paced courses was equal to that of conventional courses in 32 cases, superior in 15 cases, and slightly poorer in only one case (Orlansky, & String, 1979).

Unfortunately, the curriculum development methods were not

sufficiently proceduralized so that they could be applied by non-artists. The planning manuals adopted were supposed to be more complete than earlier ones, and more relevant to the development of training for a wide variety of military tasks. Yet a recent study of their use by 33 groups that developed 57 different courses in all the military services noted that the procedures are still not fully adequate. The main problems are shown in Table 2.

---

INSERT TABLE 2 ABOUT HERE

---

In this study, Vineberg and Joyner (1980) reported that the job-relevancy issue was often ignored and that previously existing instruction was used as a starting point for course development. Instructional methods were selected not because they were effective and efficient, but because they existed. Similarly, tests to measure job-related learning were limited to what could, rather than what should, be tested. Evaluation of training, according to Vineberg and Joyner, received little emphasis. Feedback systems from operational units concerning job competency of graduates were not well developed. As a result, training programs needed extensive tryouts and revision to make them effective. These findings suggest that, at present, implementation of instructional planning methods has not succeeded in guaranteeing that training is always job-relevant, as efficient as possible, or effective.

How can it be that these problems result even though the procedures are supposedly more complete than earlier instructional design systems? It is our view that these problems are the result of the fact that the techniques often specify "what to do" in detail, but not "how to do it" let alone "how to do it well."

It might be useful to underscore this point. For someone who is very knowledgeable and skilled in a particular discipline a simple reminder that something should be done may be sufficient. This is why a simple checklist works well to remind highly skilled people of the steps they're to carry out on a complicated task. In the development of procedural guidelines for instructional development the adequacy of the guidance for inexperienced people such as instructors and teachers, is the issue. Much more specific "how to do it" information must be provided.

An interesting analogue of this problem was discussed in a recent paper by Norman, Gentner, & Stevens (1976). In a cookbook meant for experienced chefs, they found a recipe for mayonnaise to be six sentences long (plus a list of ingredients). In another book, intended for less experienced cooks, the same recipe was over thirteen times longer, some 900 words plus

ingredients Even with this recipe, a complete novice in the kitchen would have difficulty in completing it successfully.

Are instructional recipes much different? Their adequacy depends on how well the persons doing the work understand what has to be done, and all the steps in the process. To show the difficulty with the level of the "recipes" presented in recent guidelines, consider that out of a 36-page section on developing instruction, only two paragraphs--four sentences--tell how to develop printed instruction, and only one of those sentences offers real guidance: "Write all the student needs to know about each learning objective, but do not write one word more." (Branson, et al, 1975, Vol. III, pg. 246). Does this provide sufficient guidance for a person inexperienced in techniques of instruction and communication, and relatively ignorant about instructional psychology, test methodology, and other issues?

The fundamental problems in the adequacy of instructional system planning guidelines lead also to problems in managing the process. The management problems are further complicated by the fact that managers may be unaware of them. Training development managers often treat the system planning model and procedures as if they were complete and adequate, and assume that if an instructor or teacher merely follows "the book," the instruction will be adequate. There is little or no recognition of the variability caused by the inadequate procedures, or by inexperienced people doing the development. Since current guidelines contain no methods for assuring the quality of materials as they are developed, managers pay little or no attention to that quality. They don't know how. Rather, they consider the development of training to resemble assembly-line production, and thus, the documentation of each step in the process receives more emphasis than the way the inadequate guidelines affect instructional quality. This trivialization of the process can and does result in inadequate programs that need numerous revisions to make them job or performance relevant. Managers tend to be satisfied when all tasks and forms are completed, even though students may falter (Montemerlo, 1979, Vineberg & Joyner,1980, Hodak, Middleton, & Rankin, 1979, Miller, Swink, & McKenzie, 1978). This approach or perspective creates a gap between instructional psychology on the one hand and those people presumably "applying" it on the other.

In conclusion, the systematic planning approach to designing instruction does work,-- after a fashion. It has changed substantially the way in which instruction is designed and developed in military organizations, and the way in which instruction is carried out.

The engineering techniques, however, are not as effective as we might like them. Materials produced are criticized as being boring or worse. Yet the basic framework is good --it insures that the instruction is relevant by an analysis of what the

student needs to know or do; it provides guidelines for designing learning experiences that are appropriate to the subject matter, and in a number of studies it has increased the efficiency and effectiveness of instructional programs.

What we've just discussed is that we don't practice what we preach as well as we could, sometimes because we don't know how, sometimes because we are not careful enough to manage things well. In spite of our attempts to organize things to remove the need for the high levels of artistry described at the beginning of this section, we have not been able to do so with as much success as we had hoped for. Our recipes are not good enough.

## 4.0 Research Support for Instructional Design, Development, and Delivery.

Researchers in cognitive-science/psychology, learning, educational psychology, and instructional psychology have been investigating how people process information and learn, with the long range intention of discovering techniques applicable to the development and delivery of instruction (Wittrock, 1978). That is, they have been investigating methods, models, techniques, theories aimed at understanding performance on tasks, and this better understanding has potential for making the recipes we have better. This "relevant" trend in research has being growing over the last 20 years. Glaser argues that the motivating force behind the growing domination of cognitive psychology is concern for practical problems (1978a).

### 4.1 What is relevancy?

Klahr (1978) in a symposium relating cognitive science and instruction suggested several criteria that can be used to gauge the "relevancy" of research of this type. Since we think that his suggestions have merit, we will use them as a basis for the following discussion. The first criterion is that the tasks studied are chosen from tasks actually taught. The benefit is that observation and analysis of people learning real tasks can uncover processes of learning and remembering that are likely to occur in the classroom. This information can be used to develop prescriptions for improving teaching. Studies in which the tasks are only superficially similar to those important in schooling require considerable mental gymnastics to make recommendations for instruction.

The other criteria Klahr suggests for judging the relevance of research for instructional purposes focus on methodology and theoretical orientation. He suggests that studies using a detailed, intensive analysis of the task, and of the moment-to-moment behavior generated by subjects performing the task are more likely to come up with usable information than those that don't. Similarly, attempts to construct "information processing" descriptions or theories that characterize the interaction

between the learner's knowledge, cognitive strategies and task requirements seem more likely to support direct prescriptive action that will be effective.

If we take these criteria seriously, the use of the term "relevant" to describe some of the educational and cognitive research that is done and published is misleading. It engenders expectations that we should be able to utilize the results for teaching. We believe that this is one of the reasons for the concern about the impact research has had on teaching. Authors suggest that their research has relevance to instruction because it is "topically" similar to something that people have to learn to do in school or on jobs? Similarly, claims of relevance are made because the conditions that are manipulated are "globally similar" to conditions that occur in the classroom. Some of this research, reported as instructional research, i.e., research which is supposed to have meaning for instructing, is related so distantly that a considerable effort would be needed to translate the results into usable form. Furthermore, research claiming relevance is often of very limited scope, investigating learning or memory of very limited tasks (Clifford, 1973), e.g., reading or comprehending a sentence, or a paragraph. Such studies might be useful for describing the process of learning in order to build a theory or a model of representation in memory, but are too remote from the learning of complex topics in school to be relevant.

In the next sections we will look at some of the research that seems to be relevant for instructional planning and development, analyze its applicability, and finally discuss the nature of the bridging activities needed to translate relevant and applicable research into practice. For purposes of discussion we'll divide this work into three categories: (1) research that has "surface" relevance or face validity but that on more thorough analysis for one of several reasons is not applicable or translatable into practice without considerable additional effort, and (2) research that is relevant and has potential for translation and application. and, (3) efforts to synthsize research and develop prescriptive techniques. We will discuss this work in the context of the systems planning framework, pointing out which instructional development tasks the research findings support.

4.1.1 Examples of difficult to translate instructional research.

Many research topics fall into this category, especially those little concerned with the content of instruction. Using Klahr's characteristics of relevancy, they do not use or derive the task from an actual school task. The moment to moment interactions between the students and the task are ignored. And, no precise description or modeling of the process is undertaken. Most research studies concerned with media fall into this

category, e.g., the comparison of TV with standard lecture, computer-based presentations with lectures, films in color with films in black and white, or stills, etc. Also research on variables such as class size lack the characteristics of relevancy, as does research on classroom climate, and teacher characteristics.

It may be surprising to some that studies assessing the effectiveness of procedures like note-taking or underlining on text comprehension also fall into this category. This is a widely recommended study strategy. However, the effectiveness of such procedures depends on the students skill in identifying the "important" materials that may be tested. A recent paper reviewed the somewhat confused research on this issue and concluded that it might be better to have the teacher do the underlining (Hartley, Bartlett, & Branthwaite, 1980). After all they know what they will be testing. In any case, specific prescriptions about note taking are not likely to be derived directly from this type of research. The results of studies by different authors, using different materials, different and unspecified student population are often contradictory and confusing. Similar problems exist in research on "Discovery Learning" method. Different researchers use widely different content, ignore analysis of the content, and pay only indirect attention to the processes of discovery that students may or may not have. Results from such studies don't allow us to derive direct prescriptive recommendations to guide the design and development of instruction. Research evaluating teaching methods and ignoring content and the skills and knowledge of students is only superficially relevant (cf, Roughead & Scandura, 1968).

Another idea for assisting student learning that has been studied extensively is "Advance Organizers." The work began during the 1960's by Ausubel and his associates (1968) and is continuing today (Mayer, 1979). Even so, after many studies, it is difficult to prescribe how to construct an advance organizer to improve student learning. The problem seems to be that no one has quite decided what an advance organizer is. Without a good operational definition, the development of procedures and rules for generating advance organizers is impossible. What is needed is a to accomplish this is a model of how students interact with advance organizers and how advance organizers affect memory, comprehension, cognitive structures, study behaviors and expectations of what will be tested. A model of this sort could provide a basis for devising rules for writing advance organizers. At present we are a long way away from being able to translate the research on advance organizers into practical application except in a very global fashion.

Another research area that has received considerable attention is the effects of adjunct questions on learning. Here too, in spite of the intuitive validity of the idea that asking questions of people about what they are learning should enhance

it, considerable confusion exists among the results of many studies. Prescriptions for how to design appropriate questions are not available. Most studies do not take materials and tasks directly from those used in schooling. The design of questions is often vague, and the effect questions have on student processing activities is not a directly studied.

Research on prose comprehension has been increasing rapidly, and is often cited as being relevant for teaching (Glaser, 1978a; Wildman, 1980). The work is important and interesting. It has provided considerable advances in psychological theory. It is over-optimistic to expect that this work will lead to guidance for instruction very soon. The work (mostly) doesn't meet Klahr's criteria, and it will take substantial effort to analyze the work and translate it into prescriptive rules for designing instruction.

In conclusion, while much of the work just reviewed may be necessary and important for scientific purposes, it is of limited relevance to instruction. That is, there are no immediately obvious instructional applications. Calling it relevant is misleading , it leads people to expect we can do something simply, quickly, and straightforwardly, when in fact it is not possible.

4.1.2 Relevant and potentially translatable research.

There is a growing body of research and theory that seems to us to provide better opportunity for translation into prescriptions for instruction than the work just discussed.

The criteria for relevancy suggested by Klahr (1978) and cited above, describe the approach taken by a growing body of researchers which we believe has strong potential for providing guidelines for carrying out the instructional design tasks we have mentioned. We would like to add the reservation, however, that, although these efforts are more relevant than those described earlier, systematic attention is needed to organizing what has been or will be learned into useable procedures for those who must develop instruction. Without this effort, the impact of the research on instructional practices may be delayed or prevented entirely.

Let's look briefly at some examples of research possessing Klahr's relevancy characteristics, and then discuss what aspects of instructional design are likely to be affected. In his introduction to Advances in Instructional Psychology Glaser (1978a) highlighted several topics that have been the focus of research attention and will shape the field of instructional psychology. First, as did Klahr, he suggests that the analysis of tasks that are, or are close to the subject matter of instruction and the examination of the cognitive processes involved in learning them, is very important. The trends in the

examination of theorem proving in geometry, solving problems in physics and in other practical areas, are prime examples. The major emphasis is on developing and using analytic techniques to specify the nature of the tasks in terms of the cognitive processes and the knowledge structures possessed or needed to learn and perform the tasks. This will allow the specification of cognitive objectives to assist in instructional planning (cf, Greeno, 1976,1980; Gagne, 1979). Other work, analyzing and describing the knowledge structures and the processes used by highly skilled "experts" and contrasting them with those used by novices or just competent people, may provide means for better structuring and sequencing instruction for more effective training.

It is our view that the most fundamental problem in designing instruction is in accomplishing learning analysis. Everything that follows in the schema for planning instruction depends on the adequacy of the analysis: specifying objectives, sequencing and structuring them, development of testing to see if they've been achieved, diagnostic analysis of errors made on the test, and the forms of instruction appropriate, i.e., matching instruction to student learning strategies, designing intermediate learning activities, choosing appropriate graphic representation, and determining when simulation is appropriate. All these tasks depend on some "deeper", more accurate, analysis of what is to be learned than is currently used for instructional design.

Methods of analysis currently used tend to be superficial, concentrating on straightforward descriptions of the terminal performance desired, without much consideration of the underlying knowledge or cognitive skills needed by people to learn and perform the task. Task analysis of this sort attempts to specify processes or procedures that would be used in highly efficient performance of some task. The resulting description is of an ideal, efficient, performer who does the task in a few moves, makes no errors, and, as a result, does little backtracking. This task analysis methodology is derived from the description of job-tasks, or of subject matter content. It doesn't take into account limitations in learning ability, student background, perceptual skill or misunderstandings. Although this rational task-analysis methodology can and has provided descriptions of what has to be learned...and therefore, what to teach, it ignores much of the psychological basis for student learning, and, therefore, provides little basis for selecting appropriate instructional means (Resnick & Ford, 1976). It seems preferable to have the goal of maintaining contact with psychological theory that uses good analytical techniques. This will push the development of the techniques and theory along, iteratively refining them and making them more generalizable.

If we look at the research highlighted as important or relevant by Glaser (1978a) and Klahr (1978) regardless of the

topic, we see that the primary basis for the improvement or importance of the research over earlier work is that better techniques of analysis are being developed and used. Tasks are being studied that are either drawn directly from among those taught in school or closely related to them. The analytical methods used describe the underlying knowledge structures, cognitive skills and procedures needed to perform the tasks. Such description allows identifying what needs to be taught. Furthermore, concern for analysis of the initial performance stage and how it differs from later, competent performance, can suggest differences between novices and experts that suggests ways of making the progress from novice to expert smoother. Because of this, we suggest also that the research will have substantial impact. Analyses of tasks that have to be taught, of student experience and knowledge brought to the learning situation, and of ways to bring the two together can contribute much to the instructional system planning process. There is one caution in order, though. Although the more relevant research seems more likely to be translatable than other research, considerable effort may still be required to develop a useable technology for design. Let's describe a couple of these efforts to underscore this point.

4.1.2.1 Diagnosing "bugs" in people"s processing. In some recent work attempting to examine students' mathematical skills and build a model or theory describing those skills, Brown and Burton (1978) at once demonstrate the power of better analytic techniques, a concern for cognitive processes that underlie performance, ways of assessing those processes, and suggest ways of overcoming deficiencies in students' performance. A usual teaching practice when encountering errors on arithmetic tests is to indicate the error to the student and prescribe more practice. Brown and Burton suggest that this practice is based on an assumption that students don't follow procedures well, and that errors represent erratic, unsystematic behavior. By means of detailed analysis of performance in solving subtraction problems and examining the errors made, they were able to show that the errors were produced, not by erratic use of subtraction rules, but rather by systematic misapplication of the rules, which they conceptualized as "bugs" or faults or misconceptions in the procedures students use. Their approach is to build a model of the procedures students use in solving subtraction problems, and, given certain errors, analyzing their consistencies and suggesting why particular mistakes are made.

The procedural analysis that they used has several advantages. It provides a basis for diagnosing and correcting student errors. In their work, Brown and Burton utilized a computer program to determine the consistencies of the errors students make. Once the "bug" is detected, specific instruction can be given to correct it. They also developed a game called BUGGY to familiarize student teachers about the possible underlying reasons for student errors. The game requires the

teacher to identify the procedure producing certain errors, and this exposure improved their ability to detect them. Their work not only demonstrates the power of the analysis of student cognitive processes in carrying out a complex task, it has direct suggestions for how to carry out learning problem diagnosis in this particular task and suggests remedial instruction. As a general approach to a wider variety of tasks it obviously needs considerable further development. Techniques are needed to train individuals to do this kind of analysis for other tasks.

4.1.2.2 Developing methods to design instruction for difficult to teach tasks. A project described by Case (1978a,b) exemplifies a somewhat more extensive attack on an instructional problem and development of techniques for instructional design. Based on theoretical summaries of research assessing programs designed to teach cognitive-developmental competencies done by Piaget and Pascual-Leone, Case derived nine characteristics that successful instruction must have, and he applied them prescriptively to the development of instruction for a problem found difficult to teach to first graders: the missing addend problem, e.g., 4 + _ = 7 ("four plus box equals seven").

In research on teaching children to judge correctly which of two different sized beakers has more water, or which mixture of juice and water is stronger, or which side of a balance scale will go down, the problems elicit strategies from children that are reasonable but incorrect. In addition, correct strategies for solving these problems place a greater burden on the child's working memory than his or her own incorrect ones. The child makes errors because of this, and persists in making errors in the face of conventional instruction. If instruction is to be successful, Case concludes that it must: (a) demonstrate to the student that his of her current strategy is incorrect or can be improved upon, and (b) must minimize the load on working memory. From the research Case derives nine general rules (six for teaching the correct strategy, and three for minimizing memory load) for designing instruction to overcome these difficulties. These are shown in Table 3.

---

INSERT TABLE 3 ABOUT HERE

---

With these rules Case designed a program of instruction for the missing addend problem. Dramatic improvement in learning was found comparing students receiving the systematically designed instruction with those receiving the standard version. Case (1978b) reports that these prescriptive design rules have been used successfully to develop instruction for a number of other tasks such as, telling time, adding fractions, and remedial phonics. He concludes that the rules work and suggests that they can be used more widely in designing instruction for other

difficult classroom tasks.

Although this work provides important and potentially useful prescriptive procedures for the tasks of design, some additional effort is needed to prepare the techniques for others to use. The recipes need to be elaborated somewhat for use by some intended group of users, and perhaps placed in a manual. The user group has to be trained to prepare instructional materials and their performance needs to be monitored. This step of technology transfer might be quite straightforward in this instance. The following section describes some other approaches to developing prescriptive techniques from research and translating them into procedures to be followed by people designing instruction.

### 4.1.3 Translating and synthesizing efforts

The size of the educational research literature, as well as the psychological research literature generally, has been growing exponentially for the past ten years. It is obvious that such volume alone, calls for efforts to review, collate, organize, analyze, and synthesize this information to make it understandable and useful. The findings reported in the various studies are too varied to be understood easily. Different studies, even when they examine the same problem, use different materials, methods, students, data analyses, and so on. We have already suggested that much of the research is distant from actual instructional situations and requires considerable effort to review and analyze before it provides useful information for instructional design. Recently, Glass (1976) suggested that a technology of "integrative analysis" or "meta analysis" is needed and he described some of the approaches that could be useful. Glass used these techniques in reviewing and synthesizing the results of studies attempting to determing the effects on student achievement of different class sizes (Glass & Smith, 1978). Although the "bold generalizations" from this synthesis have been challenged recently, the approach is a good example of the type of summarization that could be useful in identifying important instructional variables. Another paper reported reviewing ten years of research studies covering a variety of topics such as individualization, systematically planned instruction, the use of questionning and advanced organizers, time spent on the learning task, etc. The summarization indicates the proportion of studies in which the manipulation had positive effects on student achievement Since many of the studies were done using classroom tasks this information suggests where useful instructional procedures may be found and where further analytic research might be profitable.

There are some other kinds of synthesizing efforts that we would like to highlight. There are two in which we have been involved directly; the derivation, from both research knowledge and logical analysis, of techniques for assuring the quality of

instruction, and for developing criterion-referenced tests. There are others that we will mention briefly, including techniques for teaching concepts derived from the extensive research literature on that topic, and "Mnemotechnics" based on the research done on the role of imagery and mnemonic devices in memory.

4.1.3.1 The Instructional Quality Inventory. When we encountered the instructional system planning model that the military services adopted in 1975 (Branson, et al, 1975, Branson, 1979), we recognized that at several points in the design and development sequence intermediate products had been developed, e.g., objectives, test items, segments of instruction. Although there was a general admonition to be concerned with the quality of what had been developed, there were no techniques specified for doing this. This lack is especially unfortunate because later steps in the development process depend on the quality of the analysis and specification of goals and objectives. M. David Merrill and his colleagues proposed to develop quality assurance techniques based on their reviews of instructional research to determine what tested or valid principles for prescribing instruction were available (see, Merrill and Boutwell, 1973). These were arranged into a manual to train and guide an evaluator to examine instruction and determine whether or not it conforms to those prescriptions (Merrill, Richards, Schmidt & Wood, 1977). Some empirical tests of the prescriptions were made and a number of workshops were given to determine how usable the techniques were (Merrill & Wood, 1977; Merrill, Wood, Baker, Ellis & Wulfeck, 1977; Wood, Ellis, & Wulfeck, 1978). Feedback from the workshops allowed us to revise the procedures extensively and finally the name: Instructional Quality Inventory (IQI). Manuals for assisting the process and for training users have been published and are being used within the Navy Education and Training Command to help in instructional program development (Wulfeck, Ellis, Richards, Wood & Merrill, 1978, Ellis, Wulfeck & Fredericks, 1979, Fredericks, 1980, Ellis & Wulfeck, 1978). Merrill, Reigeluth, and Faust (1979) reported on their version of the procedures, and Reigeluth discussed the use of a version of the procedures for training classroom teachers (1980).

The quality control procedures were derived by first inspecting the knowledge base regarding instructional strategies and testing learning progress. Then these were arranged into a form usable by instructors and others engaged in instructional development. Through "formative" tryouts the procedures were refined, confusions were removed and difficult steps simplified. The tryouts or workshops also provided an important means of familiarizing the potential user community with the technique. This kind of process is a necessary "bridging" activity in translating research knowledge into practice.

4.1.3.2 Criterion-Referenced Testing. We have undertaken to develop procedures to guide criterion referenced test deveopment

in a manner similar to that used in developing the Instructional Quality Inventory.

The systems planning model requires tests that directly measure aspects of performance or knowledge required in course objectives. Tests of this type are called "criterion-referenced" (Glaser & Klaus, 1962) meaning that an individual's test performance is compared--referenced--to an absolute objective or criterion indicating what a person must know or be able to do. Quite different problems are confronted in developing and using these tests in contrast to norm-referenced tests.

In addition to determining that an individual can do or does know whatever is required by instructional objectives, it is necessary to be able to determine why a student cannot perform well so that problems or errors may be corrected. In the systems planning model, the primary emphasis in testing during instruction is not on ranking students or on certifying achievement, but rather on diagnosis and remediation. Whenever remediation is prescribed on the basis of test results, diagnostic tests are needed.

Although both criterion-referenced and diagnostic tests are needed in the systems planning model, guidelines for developing the former are incomplete, and for the latter are non-existent in current instructional development manuals. Not surprisingly, there are substantial shortcomings in current testing methods. One problem is that selected-response tests (multiple-choice, matching, true-false) are used heavily, but are often inappropriate for the content being tested (one cannot easily test recall or hands-on performance with selected-response tests).

A second problem concerns the development of performance tests, and simulated performance tests. How does one measure proficiency in a "real" hands-on task, and how does one diagnose? Further, if time, safety, or resource constraints prevent testing real performance on real equipment, what are the best strategies for testing using simulation?

There has been a substantial amount of research and development concerned with testing over the last fifteen years, much of which has application in the systems planning model of instructional development. This includes work by Bormuth (1970) on constructing test items and subsequent work by others along the same lines, work by R. C. Anderson (1972) on constructing tests to measure "comprehension," work by Hively and his co-workers (e.g. 1968, 1974) on developing sets of test items which fully test a content area, substantial work in the Military on developing job-performance tests and simulators (e.g. the Army's Skills Qualifications Test (SQT) program), work on constructing written simulations (e.g., McGuire, Solomon, and Bashook, 1976), and work on procedures for test development (e.g. Popham, 1971,

1975; Sweezey and Pearlstein, 1974; Roid and Haladyna, 1980). In the area of diagnostic tests, work by Durnin and Scandura (1973) and Brown and Burton (1978) is leading to clear prescriptions for building tests which can pinpoint areas of student difficulty and target remediaton efficiently. Glaser (1981) has recently called attention to a variety of directions in which research in criterion-referenced testing can proceed, including diagnosis of arithmetic and writing skills, rule assessment in knowledge of scientific concepts, understanding expertise, analysis of intelligence and aptitude, and metacognitive skills.

Even though there is substantial research remaining to be done, enough information has been developed so that prescriptive methods for building effective criterion-referenced and diagnostic tests can be specified. We are currently involved in synthesizing the work described above, with the aim of devising "recipes" for instructional designers to use in developing tests for use during instructional programs.

It should be emphasized that all the techniques which we feel can contribute to the development of testing methods are analytic in nature, not statistical. In fact, we believe that much of the psychometric work on criterion-referenced testing is at best only of peripheral interest, and at worst, misdirected. For example, mastery standards for tests should be determined from an analysis of the content to be learned and tested, not from some statistical properties of test items. Similarly, test length is an analytic problem. A major difficulty with current psychometric research is its concentration on written, multiple-choice, test items. As we indicated above, this type of test item is inappropriate for testing recall of knowledge or performance skills. Yet these types of instructional content constitute a substantial portion of many instructional programs. Therefore, most psychometric techniques for "constructing" criterion-referenced tests are at best of limited applicability. In general, it is our view that the major problems in test construction involve analyzing content, then developing items which are congruent with the instructional objectives. There are no psychometric methods we know of which have anything to say about accomplishing these tasks.

4.1.3.3 Teaching Concepts. One instructional content area in which design "recipes" are well worked out is the area of "concepts." Concept tasks are those which require the student to identify, sort, classify, or categorize instances (examples or non-examples) according to characteristics or "attributes" that define category membership.

The area of concept acquisition has had a long history, beginning with work in discrimination learning, then with work in mathematical psychology, and later with work in "information processing" models of concept learning. This work culminated in sets of design prescriptions for teaching concepts. A review of

this history may be found in Lewis (1980).

From an instructional design point of view, the technology basically involves: (1) analyzing the conceptual task to identify necessary and sufficient "critical" attributes which define examples and non-examples of concepts; (2) analyzing variable attributes of examples and non-examples (variable attributes include both "correlated" attributes which are neither necessary nor sufficient for classification but which frequently occur in examples, and "irrelevant" attributes which are neither critical nor correlated); (3) designing concept instruction, which includes specifying illustrative examples and non-examples, matching or pairing them with respect to presence or absence of critical attributes, and arranging them so as to "diverge" on variable attributes, specifying categorization "rules" which define for the student the basis of classification, and constructing suitable classification practice and appropriate classification tests.

As stated above, this technology has been well developed. Good prescriptions for designing concept instruction may be found in Markle and Tieman (1969), Klausmeier (1980), and Merrill and Tennyson (1977). An up-to-date review of research and design literature in concept learning in the context of the systems planning model is given by Lewis (1980).

4.1.3.4 Mnemotechnics. This term refers to prescriptive techniques for generating procedures or materials for learning and memory enhancement. They have been developed from research on both elaboration strategies that students use normally in memorizing arbitrary lists of materials (Montague, 1972, 1977; Atkinson and Shiffrin, 1968), and the use of prelearned memory aids, or mnemonic devices (Bower, 1972). In the system planning approach to training development used in the Navy a set of mnemotechnics are included that have been developed by Braby, Kincaid and Aagard (1978). The guidelines indicate when to and when not to employ mnemonic aids, and then outlines several ways of incorporating them into instructional materials. Examples of the way in which the techniques can be used are given, as well as opportunity to practice using them. In evaluations of the techniques where people developing instruction prepared new materials, the techniques were usable, and the instruction more effective than that merely requiring learning the items (Griffith, 1979). Recently, an author aiding system using a microcomputer was developed and tested successfully (Braby, Parrish, Guitard, & Aagard, 1978). This allows an instructor to develop materials on-line, as the program suggests ways s/he should use the mnemonics.

These four examples of techniques derived from a synthesis of research and systematic planning represent good examples of some of the bridging activities necessary to apply research knowledge and increase the efficiency and effectiveness of

instruction. Perhaps it is important to comment that effort toward implementing the techniques is necessary, and that means a system must be set up to monitor and evaluate the implementation. There are a variety of ways in which that may be done, but that is the subject of another discussion.

## 5.0 Do we really know how to teach people better?

The preceding discussion affirms that we do but there are problems in transferring what we know into practice. One paramount problem limiting the application of instructional design and minimizing the impact of instructional research is the institution of schooling.

### 5.1 Grandma's "model" of teaching learning and instruction.

You may remember that we began with a question about whether we know more now than Grandma did about how to teach people. Since Grandma isn't here we can take some liberties and present her viewpoint for her. We contend that we know a lot that Grandma didn't or doesn't. Furthermore, as we have just observed much of what we know has been translated to explicit procedures for instructional development, and other research has the promise to be translated. Since these procedures are available, why isn't instruction done better?

Most lay-people, Grandma included, carry around in their heads a "model" of teaching, learning and instruction. Since their model depends on their experiences with these events, their "model" tends to be of the "teacher-in-the-little-red-schoolhouse" variety. This traditional "teaching-learning model" has been with us for hundreds of years, and describes what goes on in 95% of the classrooms in the Western World (Chadwick, 1979). We suggest that this model is at the core of the concern that instructional technology is ineffective, and that it plays a fundamental role behind the conclusion that research has little or no impact, or at best very indirect effect on teaching (Clifford, 1973; Getzels, 1978). Classroom instruction is carried out in a manner that suggests that it follows Grandma's recipe for schooling shown in Table 4. It is immediately apparent that this recipe violates many prescriptions we would want to include if we were to design efficient and effective instruction.

---

INSERT TABLE 4 ABOUT HERE

---

The traditional teacher-learning model has the following characteristics:

1- Most of their time (50-75%) teachers spend giving information, and asking questions. The questions asked require factual answers 2/3's of the time rather than problem solving.

2- They have resporsibility for designing testing and diagnosing what students don't know, as well as taking any corrective action.

3- The student role is passive, soaks up knowledge while in groups of about 19:1 in the United States and 30-70:1 in less developed countries. Although passive in learning they compete for grades. The student is responsible for learning.

4- Time is fixed, especially at the secondary school level, at about 50 minutes. Teachers labor is accounted for in terms of class-hours, not student achievement.

5- Course content is mostly verbal information. Attempts to introduce problem solving, creative thinking are distorted and attenuated by the limits of the situation.

6- Evaluation requires students to repeat back the verbal information. Testing only takes place a couple of times during a semester, and is norm-referenced, discriminating how much good and poor students have learned. The spacing of testing is regulated by the organization schedule, not to enhance learning.

This description of classroom teaching characterizes the mental model that most lay-people have. The characteristics of Grandma's model are not likely to be changed soon. There is a resistence of institutions to any efforts that would change the usual way of doing business (Popkewitz, 1979). This resistence prevents substantial changes from being introduced even though it might be recognized that better recipes are available. Given Grandma's model, and the resistence of organizations to change it is unsurprising that what we know about how to teach has had little impact.

The basic habits of the classroom and the way in which schools are managed provide substantial constraints on introducing radical changes, i.e. the little-red-school house resists change. Furthermore, any attempts to change it are usually adjunctive to whatever is going on in the classroom. Thus, the changes go away when the people implimenting the changes go away. A better test of the adequacy of the technology and research knowledge is their impact on changes in instruction in situations where changes are made (or can be made) to gain efficiency and effectiveness. One of these places is military training. Things are now done very differently than they were done several years ago, because the technical recommendations

from research have been followed, at least to a considerable extent.

Earlier, we discussed problems with the implementation of the system planning model for developing instruction. Job relevancy is often ignored, testing is often inappropriate for objectives, old courses dictate the instructional content and delivery, rather than decisions about efficient or effective ways of teaching, etc. One reason for this is that the people developing the instruction also have Grandma's model of instruction. Untrained people tend to develop instruction which resembles their "mental model" of teaching they learned in school. Even when people have a little training in using a system planning model, if the procedures are not explicit they lapse back to Grandma's model. They adopt existing materials, testing procedures, and instruction. The point of all this is that even when research has shown some instructional design technique to be effective, and when that technique has been translated into workable design methods, there is still an implementation gap. This gap occurs because of institutional resistance to change, and more importantly, because people think they already know how to instruct students.

5.2 What is needed?

5.2.1 Adoption of the instructional system planning model. This framework can be useful as an organizing scheme to assist in putting research into perspective. It provides a means of judging relevancy, and promotes an interplay between application needs and research attention. To do this means that the research community will have to shift its attitudes regarding application efforts somewhat. Researchers will have to become concerned seriously with the translation of research results into techniques that can be used.

In addition, if Klahr's criteria of relevance are taken seriously, problems for research will be chosen from among those of concern to instructors and instructional designers; detailed analyses will be undertaken of the interactions between student cognitive processes and instructional requirements; a change will be needed in the view of many researchers who operate under the impression that research can be converted into educational practice directly (cf, Schutz, 1979).

5.2.2 More synthesizing efforts. Design tools such as the Instructional Quality Inventory, or Concept teaching techniques, are needed to provide guidance to assist people in accomplishing the various tasks of the instructional planning process. Such efforts should include testing the usability of the procedures for the intended audience. Without this the techniques might go unused (cf, Clifford, 1973). Other synthesizing efforts or meta analyses may be appropriate for identifying difficulty in devising prescriptions that might call for further analytical

research and theoretical development to assist the design tasks (e.g., Pillemer & Light, 1980; Walberg, Schiller, & Haertel, 1979).

Design tools constructed from theory and research need to be simple to understand and use. Since they will be used by teachers and subject matter specialists for materials development, they should be relatively unobtrusive and should not require extensive training. Few design tools meet this requirement today. It has been suggested that computer-based aids to design and development may be able to meet this requirement in the future (Montague, 1979, Gibbons, 1981).

5.2.3 Organizational committment. Existing Centers of instructional research can assist in helping to develop the framework and in transitioning the technologies into practice. For example, instructional systems development centers at Florida State and Syracuse Universities, the Learning Research & Development Center at the University of Pittsburgh, and the International Objectives Exchange program at University of California, already assist by developing aspects of the technology, and in training researchers and teachers. These and other similar organizations must act as interfaces between instruction and instructional developers and the research knowledge base, using the system planning framework as a communication tool. It is apparent that teachers are undertrained regarding instructional research, psychology and design technology (Berliner, 1981). The system planning model is a useful tool for teaching them and organizing existing knowledge and techniques. Although the military has adopted the framework for designing and developing training, they have not recognized the shortcomings of the knowledge base and existing tecniques, and as a result, they have made no organizational committment to its improvement. They need to.

5.2.4 Interfacing with teaching in the schools. On several occasions it has been suggested that the applicability of existing research and techniques to schooling is limited because the variables manipulable in the classroom are not those varied in research studies (Shuell, 1980, 1981). More attention needs to be given to this interface since it is unlikely that traditional schooling will change rapidly. Techniques are needed to circumvent deficiencies in the recipe for schooling. Berliner (1981) calls for increasing training in instructional technology and psychology to develop professional levels of competency among teachers. He also suggests that schools consider hiring a "clinical" educational specialist who would work within the teaching environment to improve teaching content and practices. It is interesting that this concept has been implemented in the Navy for some time, although the professional competency of the individuals is often less than that needed for the job.

It has been suggested that computers, with their increasing

capabilities and their decreasing costs will circumvent some of the problems of classroom teaching (Brown, 1977, Collins, 1981). Although we agree that there is great potential in this technology, the difficult problems remain in the need for techniques to develop the teaching materials and in designing attractive adjuncts to the classroom.

Although schooling will have to change, it will change slowly. The changes should be planned systematically, and to do that we need research information and recipes for conversion. We should not look to schooling alone as a measure of the success of research efforts, it is a peculiar, and inflexible environment. Rather, we should look to the adequacy of the instructional system planning process for designing instruction and use it to help motivate changes in the teaching system based on well defined, and well supported recommendations from empirical research.

In conclusion, we really do know a lot about how to teach people to do things, and we will make considerably more headway if current research trends emphasizing process analysis continue. What we don't know, and most of us pay little attention to, however, is how to get the instructional system to take our advice when that advice requires substantial changes in the way in which instruction currently is done.

## References


Anderson, R. C. How to construct achievement tests to assess comprehension. Review of Educational Research, 1972, 42 (2), 145-170.

Andrews, D. H., & Goodson, L. A. A comparative analysis of models of instructional design. Journal of Instructional Development, 1980, 3 (4), 2-16.

Atkinson, R. C., & Shiffrin, R. M. The control of short-term memory: A proposed system and its control processes. In K. W. Spence and J. T. Spence (Eds.) The psychology of learning and motivation: Advances in research and theory. Vol.2. New York: Academic Press, 1968.

Ausubel, D. P., Educational psychology: A cognitive view. New York: Holt, Rinehart, & Winston, 1968.

Berliner, D Discussion: Psychological theory and educational practices: Is it possible to bridge the gap? Discussion of papers at Section 15.21 of the Annual Meeting of the American Educational Research Association, April 13-17, Los Angeles, CA, 1981.

Bormuth, J. R. On the theory of achievement test items. Chicago: University of Chicago Press, 1970.

Bower, G. H. Mental imagery and associative learning. In L. Gregg (ed.) Cognition in learning and memory. New York: Wiley, pp. 51-88, 1972.

Braby, R., Parrish, W. F., Guitard, C. R., & Aagard, J. A. Computer-aided authoring of programmed instruction for teaching symbol recognition, TAEG Report No. 58. Orlando, FL: Training Analysis and Evaluation Group, June, 1978.

Branson, R. K. Implementation issues in Instructional Systems Development: Three case studies. In H. F. O'Neil, Jr. (Ed.) Issues in instructional systems design. New York: Academic Press, 1979.

Branson, R. K., Rayner, G. T., Cox, J. G., Furman, J. P., King, F. J., & Harnum, W. H. Interservice procedures for Instructional Systems Development (NAVEDTRA 106A) Pensacola, FL: Navy Education and Training Command, 1975.

Brown, J. S. Notes for addressing the House Science and Technology Subcommittee on Domestic and International Scientific Planning, Analysis and Cooperation regarding Computers in a Learning Society. Cambridge, MA: Bolt, Beranek & Newman, October 12, 1977.

Brown, J. S., & Burton, R. R. Diagnostic models for procedural bugs in basic mathematical skills. Cognitive Science, 1978, 2, 155-192.

Case, R. A developmentally based theory and technique of instruction. Review of Educational Research, 1978, 48 (3), 439-463. (a)

Case, R. Implications of developmental psychology for the design of effective instruction. In A. M. Lesgold, J. W. Pellegrino, S. D. Fokkema, & R. Glaser (Eds.) Cognitive psychology and instruction. New York: Plenum Press, 1978, 441-463. (b)

Chadwick, C. B. Why educational technology is failing (and what should be done to create success). Educational Technology, January 1979, pp. 7-19.

Churchman, C. W. The systems approach. New York, NY: Dell, 1968.

Clifford, G. J. A history of the impact of research on teaching. In R. M. W. Travers (Ed.), Second handbook of research on teaching, Chicago, Ill.: Rand-McNally, 1973.

Durnin, J. & Scandura, J. M. An algorithmic approach to assessing behavior potential: Comparison with item forms and hierarchical technologies. Journal of Educational Psychology, 1973, 65 (2), 262-272.

Ellis, J. A. & Wulfeck, W. H. II The instructional Quality Inventory: IV. Job performance aid (NPRDC SR 79-5). San Diego, CA: Navy Personnel Research & Development Center, November, 1978.

Ellis, J. A., Wulfeck, W. H. II, & Fredericks, P. S. The Instructional Quality Inventory: II. User's manual (NPRDC SR 79-24). San Diego, CA: Navy Personnel Research & Development Center, August, 1979.

Gagne, R. M. Instruction: A basis beyond performance? NSPI Journal, 1979, 18 (10), 9-13.

Gagne, R. M. Is educational technology in phase? Educational Technology, February 1980, pp. 7-14.

Gagne, R. M., & Briggs, L. J. Principles of instructional design. New York: Holt, Rinehart, and Winston, 1979.

Gagne, K. M. & Rohwer, W. P., Jr. Instructional psychology. Annual Review of Psychology, 1969, 381-418.

Getzels, J. W. Paradigm and practice: On the impact of basic research in education. In P. Suppes (Ed.), Impact of research on education: Some case studies. Washington, D. C.: National Academy of Education, 1978.

Gibbons, A. Principles and procedures for authoring system generation. Paper presented to Section 21.32 of the Annual Meeting of the American Educational Research Association, April 13-17, Los Angeles, CA, 1981.

Glaser, R. Components of a psychology of instruction: Toward a science of design. Review of Educational Research, 1976, 46 (1), 1-24.

Glaser, R. Advances in instructional psychology (Vol. 1). Hillsdale, NJ: Erlbaum, 1978. (a)

Glaser, R. The contributions of B. F. Skinner to education and some counter influences. In P. Suppes (Ed.), Impact of research on education: Some case studies. Washington, D. C.: National Academy of Education, 1978. (b)

Glaser, R. The future of testing: A research agenda for cognitive psychology and psychometrics (LRDC Tech. Rep. 3). University of Pittsburg, PA: Learning Research and Development Center, February 1981.

Glaser, R., & Klaus, D. J. Proficiency measurement: Assessing human performance. In R. M. Gagne (Ed.), Psychological principles in system development. New York: Holt, Rinehart, & Winston, 1962.

Glass, G. V. Primary, secondary, and meta-analysis of research. Educational Researcher, 1976, 5 (10), 3-8.

Glass, G. V. & Smith, M. L. Meta-analysis of research on the relationship of class size and achievement. The class size and instruction project. San Francisco, CA: Far West Laboratory for Education Research and Development, September 1978.

Greeno, J. G. Cognitive objectives of instruction: Theory of knowledge for solving problems and answering questions. In D. Klahr (Ed.), Cognition and instruction. Hillsdale, NJ: Erlbaum, 1976.

Greeno, J. G. Significant basic research questions and significant applied research questions are the same questions. Paper presented at the Annual Meeting of the American Educational Research Association, March 27-31, Toronto, Ontario, Canada, 1978.

Greeno, J. G. Some examples of cognitive task analysis with instructional implications. In R. C. Snow, P-A Federico, & W. E. Montague (Eds.), Aptitude, learning and instruction (Vol. 2). Hillsdale, NJ: Erlbaum, 1980.

Griffith, D. A review of the literature on memory enhancement: The potential and relevance of mnemotechnics for military training. (TR 436) Alexandria, VA: U. S. Army Research Institute for the Behavioral and Social Sciences, December, 1979.

Gropper, G. L. On gaining acceptance for instructional design in a university setting. Educational Technology, December 1977, pp. 7-13.

Gropper, G. L. Is instructional technology dead? Educational Technology, January 1980, pp. 37-39.

Harmon, P. Beyond behavioral performance analysis: Toward a new paradigm for educational technology. Educational Technology, February 1979, pp. 9-14.

Hartley, J., Bartlett, S., & Branthwaite, A. Underlining can make a difference - sometimes. Journal of Educational Research, 1980, 73 (4), 218-224.

Hively, II, W., Patterson, H. L. & Page, S. H. A universe-defined" system of arithmetic achievement tests. Journal of Educational Measurement, 1968, 5 (4), 275-290.

Hively, W., Maxwell, G., Rabehl, G., Sension, D. & Lundin, S. Domain-referenced curriculum evaluation: A technical handbook and a case study from the Minnemast project. Los Angeles, CA: Center for the Study of Evaluation, 1973.

Hodak, G. W., Middleton, M. G., & Rankin, W. C. Institutionalization of Instructional Systems Development (ISD). In The Naval education and training command: An organizational analysis. TAEG Report No. 70, May 1979.

Klahr, D. Information processing models of cognitive development: Potential relevance to science instruction. Paper presented at the Annual Meeting of American Educational Research Association, Toronto, Ontario, Canada 27-31 March 1978.

Klausmeier, H. J. Learning and teaching concepts, a strategy for testing application of theory. New York: Academic Press, 1980.

Lewis, J. M. Concept attainment among postsecondary students: Instructional design and delivery. Educational Technology, July 1980, pp. 5-17.

McDonald-Ross, M. Behavioral objectives --A critical review. Instructional Science, 1973, 2 (1), 1-52.

McGuire, C. H., Solomon, L. M., & Bashook, P. G. Construction and use of written simulations. The Psychological Corp., 1976.

Markle, S. M. & Tieman, P. W. Really understanding concepts. Champaign, IL: Stipes, 1969.

Mayer, R. E. Twenty years of research on advance organizers: Assimilation theory is still the best predictor of results. Instructional Science, 1979, 8, 133-167.

Merrill, M. D. & Boutwell, R. C. Instructional development: Methodology and research. In F. N. Kerlinger (Ed.), Review of research in education (Vol.1). Itasco, NY: Peacock, 1973.

Merrill, M. D., Reigeluth, C. M., & Faust, G. W. The Instructional Quality Profile: A curriculum evaluation and design tool. In H. F. O'Neil, Jr. (Ed.), Procedure for Instructional Systems Development. New York: Academic Press, 1979.

Merrill, M. D., Richards, R. E., Schmidt, R. V., & Wood, N. D. Interim training manual for the Instructional Strategies Diagnostic Profile (NPRDC SR-77-14). San Diego, CA: Navy Personnel Research & Development Center, September, 1977.

Merrill, M. D. & Tennyson, R. D. Teaching concepts: An instructional design guide. Englewood Cliffs, NJ: Educational Technology Publications, 1977.

Merrill, M. D. & Wood, N. D. Validation of the Instructional Strategies Diagnostic Profile: Empirical studies (NPRDC TR 77-25). San Diego, CA: Navy Personnel Research & Development Center, April, 1977. (AD-A042 334)

Merrill, M. D., Wood, N. D., Baker, M. S., Ellis, J. A. & Wulfeck, W. H., II. Empirical validation of selected Instructional Strategy Diagnostic Profile prescriptions (NPRDC TR 77-43). San Diego, CA: Navy Personnel Research & Development Center, September, 1977. (AD-A045 309)

Montague, W. E. Elaborative strategies in verbal learning and memory. In G. Bower (Ed.) The psychology of learning and motivation, Vol. 6, New York: Academic Press, 1972.

Montague, W. E. Design considerations in computer-based instructional development systems. Paper presented in Section 6.04 of the Annual Meeting of the American Educational Research Association, April 8-12, San Francisco,

CA, 1979.

Montemerlo, M. D. The Instructional System Development model: Tool or tyrant? Paper presented at the American Psychological Association Annual Convention, New York, NY, 1-5 September 1979.

Montemerlo, M. D., & Tennyson, M. E. Instructional Systems Development: Conceptual analysis and comprehensive bibliography (Tech. Rep. NAVTRAEQUIPCEN IH-257). Orlando, FL: Naval Training Equipment Center, February 1976.

Norman, D. A., Gentner, D. R., & Stevens, A. L. Comments on learning schemata and memory representation. In D. Klahr (Ed.), Cognition and instruction. Hillsdale, NJ: Erlbaum, 1976.

Orlansky, J., & String, J. Cost-effectiveness of computer-based instruction in military training (IDA Paper P-1375). Arlington, VA: Institute for Defense Analysis, April 1979.

Pillemer, D. B., & Light, R. J. Synthesizing outcomes: How to use research evidence from many studies. Harvard Educational Review, 1980, 50 (2), 176-195.

Popkewitz, T. S. Educational reform and the problem of institutional life. Educational Researcher, March 1979, pp. 3-8.

Roid, G. & Haladyna, T. The emergence of an item-writing technology. Review of Educational Research, 1980, 50 (2), 293-314.

Roughead, W. G., and Scandura, J. M. "What is learned" in mathematical discovery. Journal of Educational Psychology, 1968, 61, 581-591.

Shuell, T. J. Learning theory, instructional theory, and adaptation. In R. E. Snow, P-A Federico, & W. E. Montague (Eds.), Aptitude, learning and instruction (Vol. 2). Hillsdale, NJ: Erlbaum, 1980.

Shuell, T. J. Toward a model of learning from instruction. Symposium paper, Session 15.21 of the American Educational Research Association, April 13-17, 1981.

Schutz, R. E. Where we've been, where we are, and where we're going in educational research and development. Educational Researcher, 1979, 8 (8), September 1979.

Slavin, R.E. Basic vs. applied research: A response. Educational Researcher, 1978, 7 (2), 15-17.

Sweezey, R. W. & Pearlstein, R. B. Developing criterion-referenced tests Reston, VA: Applied Science Associates, Inc. U. S. Army Research Institute for the Behavioral and Social Sciences, Contract DAHC 19-74-C-0018, ASA Report 287, September, 1974.

Vineberg, R., & Joyner, J. N. Instructional System Development (ISD) in the armed services: Methodology and application. (TR 80-1) Alexandria, VA: Human Resources Research Organization, January 1980.

Walberg, H. J., Schiller, D., & Haertel, G. D. The quiet revolution in educational research. Phi Delta Kappan, November 1979, pp. 179-183.

Wildman, T. M. Instructional design as aframework for unifying curriculum. Educational Technology, March, 1980.

Wittrock, M. C. The cognitive movement in instruction. Educational Psychologist, 1978, 13, 15-29.

Wood, N. D., Ellis, J. A. & Wulfeck, W. H. II. Instructional Strategy Diagnostic Profile training manual: Workshop evaluation (NPRDC SR 78-17). San Diego, CA: Navy Personnel Research & Development Center, September, 1978.

Wulfeck, W. H. II, Ellis, J. A., Richards, R. E., Wood, N. D. & Merrill, M. D. The Instructional Quality Inventory: I. Introduction and overview (NPRDC SR 79-3). San Diego, CA: Navy Personnel Research & Development Center, November, 1978.

Table 1

Tasks Done in Instructional System/Program Development

| | |
|---|---|
| DETERMINE NEED | Assess need for particular instruction (competence needed) |
| | Consider alternatives to instruction |
| | Identify constraints of instructional environment |
| | Calculate costs for development and implementation |
| SPECIFY DESIGN | Formulate broad goals and detailed objectives in observable terms |
| | Develop testing matched to the goals and objectives |
| | Classify goals and objectives for skill types, learning requirements |
| | Identify learners' ages, past learning, aptitudes, etc. |
| | Sequence objectives to facilitate attaining broad goals |
| | Determine instructional strategies, and presentation form matched to learner competencies and content |
| PRODUCE | Develop courseware as specified by design specifications |
| EVALUATE | Tryout instruction (1) during design/development, and (2) after program completion |
| IMPLEMENT | Install, monitor, and maintain instruction |

Table 2

Problems found in implementing the system planning approach*

* Job relevancey often ignored
* Use existing courses as models
* Teaching methods chosen because of familiarity
* Tests determined by what could rather than what should be tested
* Evaluation of training not emphasized

Usefulness of the approach

* Improves job relevancy, eliminates irrelevant content
* Shortens time used in instruction
* Self-pacing partially adapts to students

Table 3

Rules for Designing Instruction

A. Developing the correct strategy.

a.1 Provide some means for the student to assess the adequacy of his or her current strategy.

a.2 Provide the student with a problem situation where the inadequacy of the current strategy can be seen.

a.3 Provide a simple explanation for why the current strategy is inadequate.

a.4 Provide a clear demonstration of the correct strategy.

a.5 Provide a clear explanation of the reason why the correct strategy works.

a.6 Provide practice, coaching, and practice generalizing the strategy.

B. Minimizing memory load.

b.1 Minimize the number of items of information the student must attend to.

b.2 Use familiar cues and require familiar responses.

b.3 Insure that stimuli to be attended to stand out from context.

Table 4

GRANDMA'S RECIPE FOR SCHOOLING

INGREDIENTS

* 1 typical classroom with desks
* assorted visual presentation aids: blackboard, storyboard, projector
* 1 textbook or other prepared material, per student
* 1 teacher
* 1 50-minute hour per session
* 19 students in the U. S., 30-70 students in less developed countries

RECIPE

* have teacher spend 50-75 % of time giving information
* Once-in-awhile ask questions, make 66% of them factual
* have students listen to absorb information
* test students when convenient, each week, month, semester
* test learning by having them repeat back answers, or use multiple choice
* give students grades to rank them